Balanced Ventilation: Understanding the Options

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Description

As homes continue to become more efficient, specifically related to envelope airtightness, a greater emphasis has been placed on indoor air quality (IAQ). Mechanical ventilation systems are key to ensuring proper IAQ in new homes. For new construction, builders often debate the merits of readily available systems and strategies. This session will focus on balanced ventilation systems, specifically heat recovery ventilators (HRVs) and energy recovery ventilators (ERVs). The focus of this session will include the common benefits to builders and occupants in terms of performance and IAQ as well as the challenges of system complexity and cost.

Learning Objectives

1. Understand the code provisions related to mechanical ventilation in the 2018 International Residential Code and how they impact the selection of ventilation strategies.
2. Examine currently available equipment and system options that builders may consider when providing homeowners with a well-designed strategy.
3. Discuss the benefits and challenges of common systems, including installation, cost, complexity, and performance.
4. Identify opportunities for builders to utilize ventilation strategies and systems as selling points to potential clients.
Why is Whole-House Mechanical Ventilation Needed?

The Need for Ventilation

- Modern energy codes require tighter enclosures
  
  BUT

- Reducing natural infiltration limits the amount of fresh air available for occupants

- "Build tight - ventilate right"

2018 IRC N1102.4.1.2 (R402.4.1.2) Testing

- The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding five air changes per hour in Climate Zones 1 and 2, and three air changes per hour in Climate Zones 3 through 8. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). Where required by the building official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the building official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.
Blower Door Concept

- Depressurize the home to an exaggerated pressure difference to quantify air infiltration and compare with established benchmarks
- $\text{ACH}_{50}$ = Air Changes per Hour at pressure difference of 50 Pa
  - Current limit in Pennsylvania is 3 $\text{ACH}_{50}$
  - 50 Pa simulates roughly a 20 mph wind on all sides of the home

Airtightness Requirement: 5 $\text{ACH}_{50}$

- Measured in Air Changes Per Hour at 50 Pascals ($\text{ACH}_{50} / \text{ACH}_{n}$)
- 50 pascals – equivalent to 20 MPH wind on the house

$$\text{ACH}_{50} = \frac{\text{CFM}_{50} \times 60}{V} < 3$$

2018 Ventilation Requirements

- R303.4 Mechanical Ventilation
  - Where the air infiltration rate of a dwelling unit is 5 air changes per hour or less where tested with a blower door at a pressure of 0.2 inch w.c (50 Pa) in accordance with Section N1102.4.1.2, the dwelling unit shall be provided with whole-house mechanical ventilation in accordance with Section M1505.4.
M1505.4: Whole-House Mechanical Ventilation System

**M1505.4.1 System design.** The whole-house ventilation system shall consist of one or more supply or exhaust fans, or a combination of such, and associated ducts and controls. Local exhaust or supply fans are permitted to serve as such a system. Outdoor air ducts connected to the return side of an air handler shall be considered as providing supply ventilation.


**M1505.4.2 System controls.** The whole-house mechanical ventilation system shall be provided with controls that enable manual override.


**M1505.4.3 Mechanical ventilation rate.** The whole-house mechanical ventilation system shall provide outdoor air at a continuous rate as determined in accordance with Table M1505.4.3(1) or Equation 15-1.

- Equation 15-1: Ventilation rate in cubic feet per minute =  
    \[ (0.01 \times \text{total square foot area of house}) + (7.5 \times \text{(number of bedrooms + 1)}) \]
M1505.4: Whole-House Mechanical Ventilation System

- Exception: The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25-percent of each 4-hour segment and the ventilation rate prescribed in Table M1505.4.3(1) is multiplied by the factor determined in accordance with Table M1505.4.3(2).

2018 IRC Table M1505.4.3 (1) & (2)

<p>| CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS |</p>
<table>
<thead>
<tr>
<th>Dwellings Unit Size (square feet)</th>
<th>Number of Bedrooms</th>
<th>Table M1505.4.3(1)</th>
<th>Table M1505.4.3(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWELLING UNIT SIZE</td>
<td>0-12</td>
<td>13-34</td>
<td>35-56</td>
</tr>
<tr>
<td>0-1200</td>
<td>30</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>1201-2400</td>
<td>45</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>2401-3600</td>
<td>60</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>3601-4800</td>
<td>75</td>
<td>90</td>
<td>105</td>
</tr>
<tr>
<td>4801-6000</td>
<td>90</td>
<td>105</td>
<td>120</td>
</tr>
<tr>
<td>6001-7200</td>
<td>105</td>
<td>120</td>
<td>135</td>
</tr>
<tr>
<td>&gt;7200</td>
<td>120</td>
<td>135</td>
<td>150</td>
</tr>
</tbody>
</table>

| INTERMITTENT WHOLE-HOUSE MECHANICAL VENTILATION RATE FACTORS |
| RUN TIME PERCENTAGE | 25% | 33% | 50% | 66% | 75% | 100% |
| FACTOR | 4 | 3 | 2 | 1.5 | 1.3 | 1.0 |

Mechanical Ventilation Examples
Example #1

Small Home
• Size: 1,350 SF
• Bedrooms: 3
• Bathrooms: 1.5

Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

2018 IRC Table M1505.4.3 (1)

<table>
<thead>
<tr>
<th>DWELLING UNIT FLOOR AREA (square feet)</th>
<th>0 - 1</th>
<th>2 - 3</th>
<th>4 - 7</th>
<th>&gt; 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airflow in CFM</td>
<td>&lt; 1,500</td>
<td>30</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>1,501 - 3,000</td>
<td>45</td>
<td>60</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>3,001 - 4,500</td>
<td>60</td>
<td>75</td>
<td>90</td>
<td>105</td>
</tr>
<tr>
<td>4,501 - 6,000</td>
<td>75</td>
<td>90</td>
<td>105</td>
<td>120</td>
</tr>
<tr>
<td>6,001 - 7,500</td>
<td>90</td>
<td>105</td>
<td>120</td>
<td>135</td>
</tr>
<tr>
<td>&gt; 7,500</td>
<td>105</td>
<td>120</td>
<td>135</td>
<td>150</td>
</tr>
</tbody>
</table>


Example #2

Medium Home
• Size: 2,300 SF
• Bedrooms: 4
• Bathrooms: 2.5

Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center
## 2018 IRC Table M1505.4.3 (1)

<table>
<thead>
<tr>
<th>DWELLING UNIT FLOOR AREA (square feet)</th>
<th>NUMBER OF BEDROOMS 0-12</th>
<th>13-34</th>
<th>35-56</th>
<th>&gt;56</th>
<th>AIRFLOW RATE REQUIREMENTS in CFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5,000</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>5,001 - 7,500</td>
<td>45</td>
<td>60</td>
<td>75</td>
<td>90</td>
<td>105</td>
</tr>
<tr>
<td>7,501 - 10,000</td>
<td>60</td>
<td>75</td>
<td>90</td>
<td>105</td>
<td>120</td>
</tr>
<tr>
<td>10,001 - 12,500</td>
<td>75</td>
<td>90</td>
<td>105</td>
<td>120</td>
<td>135</td>
</tr>
<tr>
<td>&gt;12,500</td>
<td>90</td>
<td>105</td>
<td>120</td>
<td>135</td>
<td>150</td>
</tr>
</tbody>
</table>


### Example #3

**Large Home**
- Size: 5,300 SF
- Bedrooms: 6
- Bathrooms: 4
Whole-House Mechanical Ventilation Options

3 Design Solutions For Whole-House Mechanical Ventilation

- Exhaust-only
- Supply-only
- Balanced system

Exhaust-Only Ventilation
How a Balanced System Works

- Balanced ventilation systems combine supply and exhaust systems
- Most systems have built-in heat recovery capabilities so that heat is transferred between the exhaust air and the supply air
- Some systems are also capable of transferring moisture

Balanced Pros/Cons

**PROS**
- A balanced system transfers heat which increases comfort and decreases the load on the HVAC system
- A balanced system maintains a neutral pressure difference which in turn reduces the strain on the building thermal envelope

**CONS**
- Highest installed cost option for whole-house mechanical ventilation
- Requires regular maintenance and filter changes

Balanced Air Flow Options

**ERV aka:**
- Energy Recovery Ventilator
- Heat Exchanger
- Sensible and Latent Recovery
- Energy Wheel
- Static Plate Core
- Enthalpic Plate

**HRV aka:**
- Heat Recovery Ventilator
- Sensible Recovery
- Heat Exchanger
Common Energy Recovery
Media / Packages

HRV: Heat Recovery Ventilator
- Core material: Aluminum or Plastic
- Sensible only recovery
- 20-30% total effectiveness
- Manufacturers: Fantech, Lifebreath, Venmar

ERV: Enthalpy Wheel
- Core material: Desiccant or Enthalpic plate
- Sensible and Latent recovery
- 60-65% total effectiveness
- Manufacturers: Greenheck, SEMCO

ERV: Enthalpy Core
- Core material: Desiccant or Enthalpic plate
- Sensible and Latent recovery
- 60-65% total effectiveness
- Manufacturers: RenewAire, S&P, Mitsubishi

HRV vs ERV Does it Matter?

HRV’s
- Transfer temperature differential
- Sensible heat
- Aluminum or plastic cores
- Require condensate pan and drain – must be considered during installation
- Require defrost cycle
- Virtually no latent exchange – poor summer performance

ERV’s
- Transfer both sensible & latent (humidity) heat
- Desiccant wheels or enthalpic plate cores
- No condensate pans or drains
- No defrost cycle required
- Can be installed in any configuration
- Effective energy exchange in all seasons

HRV: Sensible Core - Review

- Numerous Media Manufacturers
- Packaged HRV Equipment
- Common Transfer material
  - Aluminum
  - Polypropylene
- Performance
  - The return and supply airstreams pass within air passages perpendicular to each other, through the plate material
  - Liquid water is a common byproduct
- Critical Media Components
  - End pan and frame
  - Defrost
  - Drain pan
  - Associated plumbing
ERV: Enthalpy Core - Review

- Transfer Performance
  - Air passages perpendicular to each airstream through the plate material
  - Sensible via conduction
  - Latent via diffusion
- Straight Air Passages
  - Laminar Flow
  - Typical Velocity: 250 - 500 ft./min.
  - Static pressure loss: 0.6 – 1.2 inch

How Does Energy Exchange Work?

- Static-Plate Core allows exhaust and outside air streams to cross paths in the core, transferring both heat and moisture in the process.

How does the Energy Exchange work?

Water molecules (vapor) and heat permeate the media
How does the Energy Exchange work?

- Allows H2O molecules (2.8 angstrom) to efficiently pass through core membrane
- SO2, NOx, CO2, etc are exhausted out of building
- No clogging when laminar flow is maintained

Fundamentals of Energy Recovery Ventilation

- Summer: Pre-cooling /drying of hot & humid incoming air
- Winter: Pre-heating/humidifying of cold & dry incoming air
- Transfers upwards of 55 - 75% of the energy in the exhaust air stream to fresh air stream

Performance Certification

- HVI Certified – Home Ventilating Institute
- AHRI Certified – Air Conditioning & Refrigeration Institute (Standard 1060)
- UL Listed – Underwriters Laboratories
RESIDENTIAL VENTILATION

EV Series available in 6 models from 50 to 300 CFM
- EV90/90P/130/200/240/300
- All feature AC fan motors
- Various controls and accessories available

EV Premium
- EV Small/Medium/Large (30-240 CFM)
- All feature EC fan motors
- Merv 13 filter optional
- Various controls and accessories available
- Hard wired version

SL75 (arriving mid-June 2022)
- One size (30-130 CFM)
- Feature EC fan motors
- Merv 13 filter optional
- Various controls and accessories available

Overview
- Ideal for single and multi-family structures, as well as light-commercial buildings
- Multiple Models
- Heat and humidity transfer using one static plate G5 core
- 2 High-Efficiency EC motor impellers on (EV Premium and SL75)
- Boost-mode capabilities to further enhance IAQ (EV Premium and SL75)
- Dial-A-Flow controller that allows setting airflow for maximizing comfort
- Indoor Only
- SL75 is replacement for discontinued SL70

Visual Overview (EV Premium)
Feature Matrix

<table>
<thead>
<tr>
<th>Feature</th>
<th>S</th>
<th>M</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Flow Range</td>
<td>30-140 CFM</td>
<td>30-225 CFM</td>
<td>30-280 CFM</td>
</tr>
<tr>
<td>Power Supply Line Cord</td>
<td>ACM Impellers or Independent Variable Speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fan/ECM Impellers</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>22 1/2&quot;</td>
<td>22 1/2&quot;</td>
<td>22 1/2&quot;</td>
</tr>
<tr>
<td>Width</td>
<td>9 1/2&quot;</td>
<td>12 5/8&quot;</td>
<td>23 5/8&quot;</td>
</tr>
<tr>
<td>Height</td>
<td>23 3/4&quot;</td>
<td>23 3/4&quot;</td>
<td>23 3/4&quot;</td>
</tr>
<tr>
<td>Weight</td>
<td>32 lbs.</td>
<td>36 lbs.</td>
<td>52 lbs.</td>
</tr>
<tr>
<td>Mounting</td>
<td>Ceiling Bracket / Wall Bracket</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter</td>
<td>MERV 8 (standard) / MERV 13 (accessory for supply outside air only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warranty Core / Unit</td>
<td>10 years / 5 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fan Efficiency</td>
<td>1.82 CFM/Watt at 51 CFM (0.2&quot; ESP)</td>
<td>2.10 CFM/Watt at 101 CFM (0.2&quot; ESP)</td>
<td>2.70 CFM/Watt at 121 CFM (0.2&quot; ESP)</td>
</tr>
<tr>
<td>Certifications</td>
<td>HVI &amp; ETL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Controls

Accessories
- Percentage Timer (PTL)
- PTL w/ Furnace Interlock (FM)
- Push Button Point of Use Timer (PBL)
- Push Button Boost Timer (PBT)
- CO2 Sensor (Duct/Wall Mount)
- Occupancy Sensor (Duct/Wall Mount)
- IAQ Sensor (Duct/Wall Mount)
- Digital Time Clock (Wall Mount/Exterior Enclosure)

Accessories
- RH Series Electric Duct Heaters (1 to 4 kW)*
- Indirect Gas-Fired Duct Furnaces are not available

Filters
- MERV 13 Available for OA Airstream

Heaters
- Automatic Balancing Valve (4, 5, 6”)
- Backdraft

Mounting
- Wall-Bracket Kit
- Louvered Wall Vents
- 6” White or Brown

Note:
- Images are of EV Premium M, SL75 has the same controls.

* Actual wattage limited by unit CFM
Maintenance

- Filters should be checked and replaced as needed
- Once a year, vacuum the four core faces using a soft brush and tool
- Core does not need to be washed as particulates do not accumulate in the core

Performance Examples

EV Premium M @ 75 cfm

<table>
<thead>
<tr>
<th>SUMMER</th>
<th>WINTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor Air</td>
<td>Return Air</td>
</tr>
<tr>
<td>DHW S</td>
<td>70°F</td>
</tr>
<tr>
<td>WHW S</td>
<td>75°F</td>
</tr>
<tr>
<td>ERHSP</td>
<td>58.4</td>
</tr>
<tr>
<td>ERHSP: M</td>
<td>105.1</td>
</tr>
<tr>
<td>ERHSP: L</td>
<td>63.0</td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>38.2</td>
</tr>
<tr>
<td>Load savings</td>
<td>0.3</td>
</tr>
<tr>
<td>Humidity removal</td>
<td>12.1</td>
</tr>
</tbody>
</table>

Note: Standard cooling conditions used for the summer performance values.
Summary

- Mechanical ventilation is required
- There are several different choices available to meet the requirement
- Balanced ventilation provides the best option (?)
- HRV/ERV provides an actual payback on the cost
- ERV's are a better choice where air conditioning and humidity are concerns